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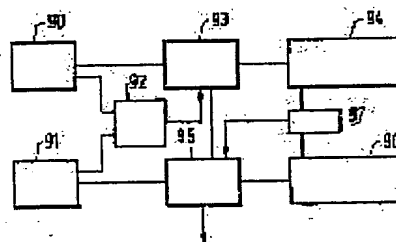
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(54) METHOD AND DEVICE FOR DETECTING PRESCRIBED SUB-CIRCUIT IN  
ELECTRIC CIRCUIT AND METHOD FOR CONSTITUTING MASK OF INTEGRATED  
CIRCUIT BY USING THE METHOD

(57)Abstract:

**PURPOSE:** To shorten calculation time required for searching the sub-circuit of a larger circuit.

CONSTITUTION: The sub-circuit is prescribed by the template element of a template circuit and the template circuit provided with an interconnection pattern among type conditions each template element relates to. This method is provided with a means 92 to count the individual occurrence rate of the circuit element of an electric circuit equivalent to satisfy an undermentioned condition for each related type condition, the means 93 to select the initial template element whose type condition corresponds to the lowest occurrence rate, and the means 95 to select a means circuit element to satisfy the type condition for a means template element. Next, in the electric circuit equivalent, until all the template elements are discriminated or continuous failures are eliminated, searching is executed for other sequential circuit element to satisfy the type condition of the template element in conformity to a pattern connected to an elimination circuit.



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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the approach of detecting the sub circuit of the electrical circuit equivalence object beforehand specified according to the type conditions to which a template circuit equipped with the pattern of the interconnect section between the interconnect template components of a template circuit and each interconnect template component relate. Moreover, this invention generates a series of description of an electrical circuit, and starts it by the initial description by the component and its connection. The consecutiveness value of the description of said single string generated by the sequential permutation of the component by the sub circuit which performs each function of said component is advanced. It is made to end by the layout description generated to said processing mask under the control which applies said pattern to the processing mask which an integrated circuit advances and performs a function. It has the feedback step which checks a sequential permutation in order to amend a sequential permutation according to a request. This feedback step leaves the intermediate description from said a series of description. The description reconfigured by advancing the template for activation of an effective component and generating of the sub circuit to adjust, and permuting an effective component is generated. It is related with the approach of manufacturing the processing mask for manufacturing the integration semiconductor circuit which was made to perform said check, by comparing said reconstruction description with the precedence value description preceded with the intermediate description of description of said single string. Furthermore, this invention relates to the equipment which detects the sub circuit where the electrical circuit equivalence object was beforehand specified according to the pattern of interconnect between the template components which interconnected, and each type conditions of the template component which interconnected.

[0002]

[Description of the Prior Art] This approach and equipment T.Kosteljik and publication "automatic verification OBU library based of B.de Loore work IC design" IEEE journal OBU Solid State It will be known from the 394-403rd page in a circuit, the 26th volume, No. 3, and

March, 1991.

[0003] An electrical circuit is usually the combination of a sub circuit. For example, a processor circuit is equipped with sub circuits, such as a memory cell, an adder circuit, a multiplexing circuit, and a logic gate, and; radio receiving circuit is equipped with a magnification stage, an oscillator circuit, a mixing circuit, a filter circuit, etc.

[0004] It is necessary to many applications to compare between an electrical circuit and a template circuit automatically. In the processing which forms an integrated circuit, there are many a series of intermediate products, such as a system level circuit description which forms the last chip, a gate level circuit description, a transistor level circuit description, layout description, and a mask. These intermediate products of a series of are formed by the equipment which may produce an error, when these need human being's mediation. It cannot be guaranteed [ which is referred to as that the great portion of today's chip is remarkably complicated, and it does not produce the error which requires these equipments that cannot be checked in fact ]. Or it enables it to amend, while preparing a feedback mechanism in these equipments, making the precedence value of the thing of a series of adjust an intermediate product again by this and distributing the error of arbitration. Even when generating in the context of the circuit where these errors are big, in order to check the intermediate product of arbitration, it is necessary to detect the sub circuit of this big circuit. Other applications of detection of a sub circuit include detection of the sub circuit which infringes on the diagnosis automated, for example and repair of a fault circuit, or a certain patent.

[0005] According to the publication mentioned above, the detail of a sub circuit with the need that a template detects in an electrical circuit, or description of the arbitration of this and equivalence is offered. To satisfy the detail which requires one of the description of the, an electrical circuit equivalence object needs to contain a template component and the component to adjust. These components contain physical components, such as a transistor, resistance, the AND gate, and a register. As for the "component" said here, the component of a template and a circuit means an input terminal, an electric power supply terminal, and also including interconnect wiring of the arbitration between physical components generally.

[0006] It has the type conditions which specify whether a template needs to make a template component (for example, a "P type transistor", an "electric power supply node", "wiring connected to the output side of the AND gate, and the input side of an inverter") adjust the

circuit element of which type to each template component. Furthermore, type conditions also pinpoint the range (for example, "the P type transistor which has width of face (10-20micro) and die length (1-2micro)", "resistance of 10-100ohm", etc.) to the parameter of a circuit element. Moreover, a template is equipped with the pattern of interconnect between template components with the need of making interconnect of a circuit corresponding when interconnect needs to identify as a sub circuit pinpointed beforehand.

[0007] As one example, the type conditions of the component of the template circuit shown in drawing 1 are as follows.

- The input AND gate and the component C2 of 1:2 components C and the C3:1st and 2nd inverters and, and component N1: -- the output side of the node and component N3:inverter connected to the output side of the node and the component N2:AND gate connected to the input side of the AND gate at least, and the input side of an inverter -- An output node and the component N4 connected to the input side of an inverter, and the input side of the AND gate: The node connected to the output side of an inverter at least and connection conditions need the next connection.

- Connection, base to an input side of connection and a component N3 to the component C1 from the output side of the connection and the component C2 to the input side of connection and a component N2 to the component C2 from the output side of the connection and the component C1 to the input side of a component N1 to the component C1 to a component N2 to a component N3 The parameter (it is (like fan-out of component C2 between 2 and 3)) range can be pinpointed in the connection pan from the output side of the connection and the component C3 from a child N3 to the input side of a component C3 to a component N4 to the component in type conditions.

[0008]

[Problem(s) to be Solved by the Invention] If an electrical circuit equivalence object detects the sub circuit pinpointed beforehand according to the publication mentioned above, it will start in consideration of an initial template component (from drawing 1 to for example, the component C1), an initial circuit element (for example, AND gate) will be chosen from an electrical circuit, and it will verify that an initial circuit element has consistency with the type conditions of an initial template component by this. Subsequently, it is necessary to choose the circuit element of the 2nd [ \*\* ] and 3rd grade, and these need to make the template

component (for example, C2, C3 grade) of the 2nd [ \*\* ] and 3rd grade correspond. It verifies satisfying the type conditions of a template component that the selected circuit element corresponds after each selection. Trying new selection until it detects selection of a circuit element and all template components are identified, when a circuit element besides; which verifies that the circuit element chosen as far as an interconnect pattern is related with the circuit element chosen before to each of the circuit element as which after the 1st circuit element others were chosen satisfies an interconnect pattern fails in this verification, this means that the sub circuit was found out.

[0009] Theoretically, it is necessary to choose and verify many possible combination of a circuit element. Therefore, in case the problem by this approach of detecting a sub circuit detects the sub circuit of an electrical circuit big enough especially, it is that the danger that there is the need of searching for many possible combination of the circuit element which does not detect a sub circuit extremely exists. Especially depending on other sub circuits used for a circuit, depending on a template and the sub circuit to adjust, an approach is made expensive and it comes to make computation time required for retrieval slow except for the briefest template and a small circuit.

[0010] Especially the purpose of this invention is to use as an offer plug the approach and equipment which detect the sub circuit in the electrical circuit of the class which enabled it to shorten computation time required to detect the sub circuit of a bigger circuit, and which was mentioned above specified beforehand.

[0011]

[Means for Solving the Problem] In this invention approach detecting the sub circuit of the electrical circuit equivalence object beforehand specified according to the type conditions to which a template circuit equipped with the pattern of the interconnect section between the interconnect template components of a template circuit and each interconnect template component relate Counting of the generating rate according to individual of the circuit element of the electrical circuit equivalence object with which are satisfied of the above-mentioned type conditions is carried out to the type conditions to which each specification relates. The initial template component with which type conditions are equivalent to the minimum generating rate is chosen. The initial circuit element with which are satisfied of the type conditions over an initial template component is chosen. It is characterized by searching

for other sequential circuit elements with which are satisfied of the type conditions of a template component until it interconnects in an initial circuit element according to said pattern in an electrical circuit equivalence object, and all template components are identified or a persistent fault is satisfied.

[0012] \*\* -- it is made like and is adapted for the electrical circuit which detects a sub circuit in the sequence which identifies a template component by the circuit element. It enables it to reduce rating with the need of detecting the count, therefore the sub circuit specified beforehand of selection of a circuit element with the need of following other retrieval according to a generating rate, using adaptation of selection line crack \*\*\*\* of an initial template component as measurement.

[0013] The observed generating rate can continue and change the magnitude between various template components to many times. Reduction of rating is attained even when the selected initial template component does not have the minimum generating rate strictly. Under the present circumstances, an important point is that selection of an initial template component is under control of a generating rate. The purpose which reduces rating from the minimum generating rate to a permissible level also by selection of those other than the generating rate in twice [ about ] is attained. This range of a generating rate is shown by presentation of the "minimum" generating rate.

[0014] A series of template components are constituted from one example of this invention approach in increment. Leave with an initial template component and it is chosen under a limit for which this interconnects the template component of the rear group of a series of template components following the pre-group of said a series of template components in a pre-group according to a pre-group pattern. The circuit element of related others which has the interconnect to the circuit element which satisfied the type conditions related to each template component, and was before chosen according to the pre-group pattern is continuously chosen in order of said a series of template components. \*\* -- it is made like and the sequence of searching for a circuit element using the sequence of the template component combined with the initial template component is controlled.

[0015] In case a pre-group limit leaves selection, it enables it to determine in other examples of this invention approach by [ both ] having the minimum generating rate of a circuit element [ / selection / of the following template component ]. \*\* -- the part of the sequence which



follows an initial template component is fitted to the generating rate in an electrical circuit equivalence object, it can be made like and also [ it is the need ] can make the following template component reduce the count of retrieval after selection of the correspond following circuit element

[0016] In one example of this invention approach, before choosing a consecutive template component, the generating rate of a template component is readjusted by removing from the generating rate of other pre-groups equipped with other related circuit elements, and a generating rate is again restricted to the circuit element connected to other pre-groups. \*\* -- it is made like and made to fit the sequence of discernment dynamically in consideration of the part of the already detected sub circuit

[0017] When a re-limit leaves selection, it enables it to re-opt for selection of a consecutive template component in the example of further others of this invention approach by having the highest connection count of the connection of the pattern which connects a pre-group to a consecutive template component. The high number of connection shows discernment of a component without the error of a fraction required for other retrieval of the conditions restricted further and a circuit element. Therefore, a workload required during detection of a sub circuit can be decreased.

[0018] When a re-limit leaves selection, it enables it to re-opt for selection of a consecutive template component in other examples of this invention approach by having the same interconnect to the pre-group of the same type conditions as the template component which carries out counting of the juxtaposition count, and said pattern. The group of a component which has the same type conditions and the same connection pattern to a template component of a pre-group is connected to juxtaposition. A PARARE rhythm performs discernment of a juxtaposition template and a circuit element in order of the permutation of \*\*\*\*. The count of necessary of the component discernment with the need of taking into consideration adjournment of discernment of this juxtaposition component is reduced until a PARARE rhythm is removed by other connection.

[0019]

[Example] The example of this invention is explained per drawing. In many applications, it is necessary to compare an electrical circuit with a template circuit automatically. With the configuration of an integrated circuit, there are many a series of intermediate products, such

as a system level circuit description which forms the last chip, for example, a gate level circuit description, a transistor level circuit description, layout description, and a mask. These intermediate products of a series of are formed by the equipment which may produce an error, when these need human being's mediation. It cannot be guaranteed [ which is referred to as that the great portion of today's chip is remarkably complicated, and it does not produce the error which requires these equipments that cannot be checked in fact ]. Or it enables it to amend, while preparing a feedback mechanism in these equipments, making the precedence value of the thing of a series of adjust an intermediate product again by this and distributing the error of arbitration.

[0020] T. Kosteljik It reaches. B.de Loore Publication" automatic verification OBU library based of work IC design"IEEE journal OBUSO lid State The approach of adjusting description of middle or a last round way with the precedence value of a series of intermediate products is indicated by the 394-403rd page in a circuit, the 26th volume, No. 3, and March, 1991. This approach is started by identifying the component according to an individual like a transistor. Subsequently, it searches for generating of the small standard sub circuit which consists of a circuit element which realizes configuration components, such as a logic gate, a latch circuit, and a multiplexer, and which interconnected by this approach. When detecting generating of this configuration interconnect, this configuration component can be permuted by the sub circuit. Subsequently, the circuit of this permutation is compared with the precedence value of a series of intermediate products.

[0021] There are various advantages in the comparison which minds [ rather than ] a sub circuit, using an indirect comparison, i.e., description of the whole circuit, directly. Probably, also in case this checks only one part of an intermediate circuit, it is effective, and moreover, it cannot separate [ 1st ] this part beforehand. Moreover, an error is distributed good, namely, an error is fixed to a sub circuit rather than all circuits. Furthermore, the result of a check shall be correspondingly applied to inspection of people also by description by the sub circuit equivalent to the idea of the man about a circuit.

[0022] Moreover, in order to realize, i.e., this approach, which can decrease a required workload using direct adjustment, it is necessary to adjust a sub circuit in a template. this adjustment -- trial-and-error -- while choosing a template component each time by :, i.e., a known approach, which is \*\*\*\*\* processing, the adjustment to a circuit element is

presumed. In other analyses, when this presumption is not right, other presumption is tried. The frequency of presumption which is not right is decreased by using the template which repeats the standard sub circuit which has a small number of component instead of one template to all the circuit elements that have many components, and is generated.

[0023] For example, for other applications like an automated diagnosis and/or repair equipment, in circuit copy equipment, an understanding of the function of a circuit is developed using detection of a standard circuit, and while this permutes a sub circuit by the equivalence object of an inventory, for example, failure can be located correctly.

[0024] How to detect a sub circuit using drawing 1 which illustrates the very small sub circuit which specifies a template is indicated it to be mind. This sub circuit is equipped with many components. These components are physical configuration components like inverters C1 and C3. Furthermore, the "component" said here shall mean the circuit node between transistors, therefore nodes N1, N2, and N3 shall also mean a component. The crossover x mark shows an output node and an input node. Although other circuits can be fixed to these inputs and an output at arbitration at the time of generating of a sub circuit, the node which is not shown as I/O is made into the connection to which it was given in the sub circuit, and can be \*(ed).

[0025] A template is formed to a sub circuit, and this template is equipped with 1 set of template components which a circuit should define in order to detect generating of the circuit which illustrates a template. Moreover, a template is equipped with the relation in which it is satisfied with the parameter of a component like the conditions about a type, and "the two input AND gates", and a list of a parameter like "the fan-out between 2 and 5." Furthermore, a template is equipped with the pattern of the interconnect which specifies the means which should connect \*\*\*\* of a template. For example, the group and type conditions of a template component are shown below to the sub circuit of drawing 1 .

C1 : 1. Fan-out <2 two AND-gate2.C2: which it has -- inverter 3.C3:inverter 4.N1: -- the output side of the node 5.N2:AND gate connected to the input side of the AND gate at least, and the input side of an inverter -- a connection pan -- the output side of a node 6.N3:inverter -- Node 7.N4 connected to the input side of an inverter, and the input side of the AND gate at least: The node connected to the output side of an inverter at least [0026] Most properties of the component relevant to;, for example, a node configuration component, to which the detailed amount of each type conditions can be changed can be specified. Although other

starting information is not omitted to adjustment, a workload required for adjustment can be decreased.

[0027] The pattern of the interconnect section can be specified as follows.

1. N1 -- Input Side of C1 -- Output Side of Connection 2.1 -- N2 -- Connection 3.N2 -- Input Side of C2 -- Output Side of Connection 4.C2 -- N3 -- Connection 5.N3 -- Input Side of C1 -- Connection 6.N3 -- Input Side of C3 -- Output Side of Connection 7.C3 -- N4 -- Connection

[0028] As for the sub circuit of drawing 1 , it is needless to say that it is one example.

Although other circuits are indicated similarly, the component (for example, register) which constitutes the component, the gate, and the other big configuration components of a type of different versatility, which carries out a component (for example, transistor) or which it has can also be used.

[0029] The problem addressed by this invention approach is detecting the sub circuit of this template and the big electrical circuit to adjust. Drawing 2 and 3 show the example of the starting big circuit.

[0030] The list of components which have description of a type and the parameter of each component can also indicate these circuits. This description is equipped with the fact which these say that they are the AND gate, the OR gate, the NOR gate, the NOT gate, and its parameter (fan-outs etc.) to the gate. Other description is transistors. The type (P type, N type), its geometry (width of face, die length), etc. express. This description is equipped with the fact which says that these are resistance and its resistance to a transistor.

[0031] Description of a type and a parameter is equipped with the fact which says that these are a node, the type of a component connected, and the input terminal connected to a node type component.

[0032] Moreover, description of a circuit is equipped with the list of connection which identifies the component which each connects. Furthermore, to; logic gate where description of connection is equipped with discernment of the terminal of a physical configuration component which connects, this means an input/output and, in the case of; MOS transistor, can presuppose that it is this a thing about the gate or a channel (the source/drain).

[0033] The sequence of a step is followed when the example of a template is what points out a circuit. As far as it chooses the circuit element with which are satisfied of the type and parameter conditions which were given to the template component in each step and the

selected circuit element is related with the component chosen at the early step, it verifies that the circuit element which had the interconnect section specified by the pattern chosen has. In having the circuit element to which all template components relate and which was chosen and verified, it detects generating of a template and the sub circuit to adjust.

[0034] Many possible combination of the circuit element which has theoretically the need of taking into consideration exists. Usually, this does not carry out depending on performing all steps according to an individual to class doubling, but when the circuit element recognized at the early stage related rather divides an early step to the same combination, it is performed.

[0035] It explains using the flow chart which shows this processing to drawing 4 . At the initialization step 30 explained for whether being mind at a detail, in; flow chart arranged in the sequence which took out the template component according to individual from the template, and attached the number, if this step is turned OFF, the template component of a number j will come to be called TC (j). ; which shows the sequence of numbering of a template component below -- it comes out enough only by considering that it was fixed by this at the initialization step to current. A flow chart explains the sequential retrieval steps 31, 32, 33, ..., 34 after this step. In each of these retrieval step, a different template component is identified to a circuit element. If a template component exists, many steps exist similarly. It symbolizes by the dot between the 3rd step 33 and the last step [ Mth ] 34, and some retrieval steps are shown, although not shown in drawing 4 .

[0036] The deformation by which each retrieval step has the same configuration, and this configuration was simplified is shown to step 2 of drawing 4 (32). Index I2 which will point at the list of circuit elements CC if an entry is carried out to a step It initializes. The circuit element CC (I2) pointed at after this tests whether the conditions over the template component TC equivalent to the 2nd step (2) are satisfied. This test includes the test for which it is not used, the test of the conditions over the type of a circuit element, and its parameter, and the test of the connection pattern which links this to the circuit element chosen at the early step at the step of an early stage [ circuit element ]. A rhombus 36 symbolizes and shows this test to drawing 4 . When a circuit element meets with a test (y), a flow chart is continued toward the following step. When an index I2 progresses to an item (37) when a circuit element does not meet with a test, and an item (38) still points at the list of template components TC, the next component of this list comes to be tried. When an another side index is in the outside of a list,

it means that selection of the circuit element as for which it was controlled by this step by this by having performed the flow chart to the front step by return carries out a back tracking. If the control from the following step is received, item (37) increase will be carried out and a back tracking will be performed by testing an item (38).

[0037] All of the retrieval steps symbolized by the retrieval steps 31, 32, and 34 and dot of drawing 4 are indexes I2. While permuting a subscript "2" by the number at a suitable step, it has the same configuration except a test 37 containing the proper template component TC to a step. If the last retrieval step 34 arrives at an outlet, this means that the sub circuit was detected in the circuit. This is reported or it is used in the report stage 39.

[0038] Theoretically, detection processing is completed now. When one or more sub circuits need to be found out in an electrical circuit, as shown in drawing 4 , control is returned to the last retrieval step 34. When there is no need of expecting the sub circuit overlapped partially, control can be conversely returned to the 1st retrieval step 31 directly. Subsequently, retrieval processing is continued. When transporting control to termination 30a by the 1st retrieval step 31, all sub circuits are found out, and it is processed by the report step 39.

[0039] Deformation of the 2nd retrieval step 32 shown in drawing 4 is simplified for explanation. Only when the template component of a step is not connected to the template component of a front step in the suitable mode in which an approach is performed especially, it is an index I2. It uses. The connection which was chosen at the early step, which is already shown a term and through which it passes is used instead of using the index which searches for all of circuit elements, when the above-mentioned connection is made. These connection expresses the point to the number to which the circuit element of relation with a circuit description and the need of taking into consideration was fully restricted.

[0040] The flow chart shown in drawing 4 traverses all the possible examples of the template of a sub circuit by traversing all the possible values to an index I1 and I2 grade. As shown in drawing 5 , this traverse is shown using the tree to the template of drawing 1 , and the circuit of drawing 2 . This drawing 5 shows the tree which has the root 50, and the level of a large number marked by "N2=", "C1=", etc. This root is equivalent to the 1st step 31 of distributed (part) processing. Each level "N2=", "C1=", etc. are equivalent to steps 32, 33, .., 34 in which the label was carried out by the specific template component identified by the circuit element (in this example, these level is equivalent to N2, C1, N3, etc. of drawing 1 ). The mutual

circuit element (Y2, Y5, Y10, Y13, Y15 of drawing 2 ) which is satisfied with each 1st level "N2=" of a branch of the root of the type conditions of a template component (N2) is shown. Therefore, the index value which continues carrying out a flow through the "y" output of the test rhombus 37 of the 1st step 31 is equivalent to Y2, Y5, Y10, Y13, and Y15.

[0041] Each path which passes through the tree from the root to a leaf on the minimum level marked with the triangle is equivalent to the sequence of the step from which the circuit element was discriminated to all template components. The reeve of the tree in the record level marked by x comes to be taken, without being equivalent to a dead edge, the combination of the discernment obtained at the early step here stopping following other discernment, and the outlet "n" of a test 38 finding out a suitable index here. Once it traverses in this tree depth first and some branches of all are traversed, it comes to carry out Bucks tetraethylpyrophosphate of the flow chart of drawing 4 .

[0042] To almost all actual circuits, the number of the branches in the root and other level (branch rate) can be made high. generating of the sub circuit which adjusts a high branch rate with a template since the number of the reeve branches of a tree with the need of carrying out a visit is the product of the branch rate in front level -- the time of detection -- it becomes count efforts mostly. The part of these efforts to be equivalent to a dead edge is not detected.

[0043] According to this invention, a number of a circuitry part with the need of choosing during retrieval of reduction is attained for a means to adjust the sequence that a template component is taken into consideration by the sequence of a retrieval step, like in TC(1) =N1, TC(2) =C1, etc. through the number of allocation to a template component at the initialization step 30.

[0044] According to this invention, the 1st template component of the above-mentioned sequence is chosen according to the minimum generating rate Nj of a circuit element of satisfying the type and parameter conditions over the template component j. As counting is carried out to the circuit of drawing 2 to the template component of the template of drawing 1 , these generating rates are as follows.

	C 1	C 2	C 3	N 1	N 2	N 3	N 4
N <sub>1</sub> =	6	7	7	8	5	2	7

[0045] theoretically, although the generating rate Nj is calculable to each template

component, while making a template component in agreement with obtaining on type conditions in a group (C2, C3) for example so that it may be C2 and C3, it is suitable to carry out once to each group. Furthermore, a circuit element can omit counting completely to a certain circuit which turns saying that it does not have the minimum generating rate in the future, and can guess it.

[0046] Therefore, according to this invention, in case it searches for the template of drawing 1, and generating of the sub circuit of drawing 2 to adjust, N3 is chosen as a template component of the one-by-one beginning. Moreover at one example of this invention, these also choose the consecutiveness value of this sequence according to the minimum generating rate with the limit which says that it is combined with the template component in front of sequence. Therefore, in case it searches for the generating rate of the sub circuit of the template of drawing 1, and drawing 2 to adjust, the possible sequence becomes as follows. N3 C1 N2 C2 C3 N4 N1 (C2 and C3 which have the same generating rate can change sequence.)

[0047] The retrieval tree which is a result from this sequence is shown in drawing 6. As for the sequence of a template component, it is needless to say by using this invention approach that it is dependent on the circuit searched for generating of a sub circuit. The generating rate in : drawing 3 from which the sequence of the circuit of drawing 2 is [ the sequence ] different to the circuit of drawing 3 is as follows.

C1 C2 C3 N1 N2 N3 N4 5 7 7 9 2 3 The sequence according to this invention approach to 7 pans is as follows.

N2 C1 N3 C2 C3 N4 N1 -- the retrieval tree which is a result at the time of applying this sequence to the circuit of drawing 2, i.e., the circuit where selection was not performed, is a retrieval tree of drawing 5 in practice. Although the amount of \*\*\*\* rare \*\*\*\*\* measured in the retrieval tree of drawing 5 with the number of nodes (a root node does not contain although the leaf node which is not successful is included) is 19, to; drawing 6, the amount of work is 14. The improvement to 14 from 19 was able to be attained by using the sequence chosen by this invention approach. In this example, this improvement is based mainly on reduction of the branch rate in the root node of a tree.

[0048] Several examples of this invention explained below prescribe the sequence of selection of a template component further. For this purpose, a weight function is introduced, and this



weight function becomes affirmative in the amount of the work expected when choosing a template component one after another one by one, or it depends for it in monotone at least. The template component which has the minimum weight value is used as sequence one after another.

[0049] Circuit element  $N_j$  which is satisfied with one example of this invention of the type and parameter conditions over the template component  $j$  It considers as the increase function of a number. The example of the weight function with which are satisfied of this is as follows. It is made like in  $F_j = C N_j$  and the branch rate of a tree is decreased ( drawing 5 /6). Positive discernment of many of circuit elements is the early step of discernment processing, namely, since the node nearest to the root goes wrong, this decreases the count of the discernment tried completely.

[0050] The sequence mentioned above is chosen according to this standard, and shows this below.

$N_3 \ C_1 \ N_2 \ C_2 \ C_3 \ N_4 \ N_1$  [0051] The various examples of this invention prescribe further in consideration of the specific circuitry relevant to the count of discernment of a positive component. one of the examples of these -- a weight function -- several [ of connection of a connection pattern ] -- it considers as the decreasing function of  $N_{cj}$  and this links each template component ( $j$ ) to the template component chosen to the early step using the weight function shown below.

$F_j = C' N_j / N_{cj}$  [0052] This is again introduced into each step on the level near the root at reduction of the number of branching branches. The template of drawing 1 is considered as one example. When components  $C_1$ ,  $N_2$ , and  $C_2$  shall be chosen at an early step, the number of the connection to each of the component which remains is as follows.

	C 3	N 1	N 2	N 3
$N_{c,1} =$	1	1	2	0

In this case,  $N_3$  is chosen immediately.

[0053] A PARARE rhythm is taken into consideration in other examples of this invention approach. The concept of this PARARE rhythm is shown in the template of drawing 6 .

Although a node 70 chooses as a template component at an early step, transistors 71, 72, 73, and 74 shall not be chosen. In this case, as far as that connection condition over the

component 70 chosen at an early stage at least is concerned, components 71, 72, and 73 presuppose that it is the same, and are connected to juxtaposition. This accumulates, and if a template and the sub circuit to adjust occur, when the juxtaposition components 71, 72, and 73 are chosen at the following step, all the permutations of discernment of a transistor will become possible. For example, when it has the circuit element to which the template components 71, 72, and 73 are chosen as, and an electrical circuit relates, all discernment with the need of taking into consideration is as follows.

71=C71 72=C72 73=C7371=C72 72=C73 73=C7171=C73 72=C71 73=C7271=C72 72=C71 73=C7371=C71 72=C73 73=C7271=C73 72=C72 73=C71 -- generally When the

juxtaposition component of N individual exists, the multiplication of the number of the branches of a tree with the need that this takes into consideration is carried out by N!. In order to prevent this increase, it is necessary to delay selection of a component parallel in this case.

[0054] This can be attained by considering as the number of the components connected to juxtaposition at the template component j, and the increase function of  $N_{pj}$  by the convention which mentioned the weight function above. ( $N_{pj}$  shows the template component j itself, therefore this is at least 1) . This weight function can be expressed for example, with a degree type.

$F_j = C7^{N_j} / N_{cj}$  [0055] For example, in drawing 7 , once a component 70 is chosen,  $N_{pj}$  to components 71, 72, and 73 is equal to 3, and  $N_{pj}$  to the P type transistor 74 is equal to 1. This accumulates, other things are equal and the P type transistor 74 is chosen at an early stage in order of a template component. Once this transistor and its gate are chosen, a transistor 73 does not become juxtaposition any longer at transistors 71 and 72, but the connection pattern to the template component chosen at an early stage will not become the same, but the gate of transistors 73 and 74 will come to be connected. This accumulates, and if the thing of \*\* is equal, a transistor 73 will come to be chosen from other two transistors 71 and 72 at an early stage in order of a template component.

[0056] In case a configuration component is connected to other terminals of a single configuration component, it is necessary to carry out a certain amount of cautions. In carrying out permutation arrangement of these terminals, without affecting the function of the function (for example, two inputs of the AND gate) of a single configuration component, although it differs, it carries out counting also of the component of parallel arbitration to juxtaposition

except the thing linked to the terminal in which permutation arrangement is possible which are other components about these.

[0057] Counting can be performed also to the component which has the group in which permutation arrangement of these terminals is possible. In the example of drawing 8, block 88a contains three physical components 80, 81, and 82 which can be combined. Let the middle component 81 be the triple line driver which connects three output terminals A, B, and C to three input terminals D, E, and F, respectively in this example. ; these terminal pairs that can carry out permutation arrangement constitute one example of the group in which permutation arrangement of a terminal is possible, without terminal pair a-d, b-e, and c-f by which each is equivalent to the input terminal and output terminal of one line driver affecting the function of a component 81.

[0058] Since permutation arrangement of the group of a terminal is carried out freely, when these perform possible discernment of  $N!$  of the terminal strapping section when the group which  $N$  individual requires exists, and template component 81 is chosen in the sequence, it comes to produce the discernment which changes by the same circuit function to a circuit element with permutation arrangement of the arbitration of the group of a terminal.

[0059] This problem is the same as that of the case of a PARARE rhythm so that equal circuit substitution product 88b may show. In this case, since the configuration components 81a, 81b, and 81c according to each are introduced to each group of a terminal and the relation between the configuration components according to individual is expressed, 81d of master configuration components is introduced (installation of the configuration component according to individual does not need to make :, therefore these of illustration which it is a sake and are purely formal correspond to an actual sub configuration component). Although it delays selection of the nodes 87b and 87c connected to the juxtaposition constituent children 81b and 81c after the configuration components 81a and 81d according to individual, and selection of that connection node 87a in processing according to the Ruhr of the PARARE rhythm which mentioned above this circuit substitution product 88b, a thing besides for that PARARE rhythm is equal. This reduces the count of desired discernment.

[0060] However, the same reduction can also be attained, without introducing the configuration component according to individual. If it shall not yet have connected other terminals of these groups to the template component chosen as the early stage of arbitration in

connecting a template component to the terminal which is a terminal and with which the group in which permutation arrangement is possible is related for this purpose, although it differs, counting also of these template component will be carried out to juxtaposition.

[0061] Before identifying theoretically the template component which has a circuit element to arbitration, a weight function can be evaluated to all template components. In the sequence of a step, the sequence of a template component can be decided from this evaluation also before discernment of arbitration. However, a weight function can also be readjusted after each sequential step. As counting of taking into consideration beforehand the component which this accumulates, for example, is used in a generating rate, or a generating rate limits to the circuit element connected to the circuit element chosen at an early stage, it can describe the identified circuit element. The sequence of the template component which is adapted for the circuit element identified at the early step by this readjustment can be chosen dynamically. However, this comes to make evaluation a sacrifice further.

[0062] According to this invention, the sequence of the template component in a sequential discernment step is used as a means to decrease a workload. Before this identifies statically the circuit element of the arbitration which has a circuit element, it is performed, or it is performed to dynamic during discernment. This accumulates and it is made to distribute the situation of the template of the sub circuit in the circuit which the count of discernment of a circuit element was decreased [ circuit ] and had the desired amount of time amount observed by this. This can be attained using one of numbers  $N_{cj}$  and  $N_j$  and the arbitration of  $N_{pj}$ , or by combining one or more of the numbers of these. Furthermore, this invention is not limited to the example of the weight function mentioned above. The function of the arbitration suitably fluctuated according to numbers  $N_{cj}$  and  $N_j$  and the combination of  $N_{pj}$  can be used. For example, the radicand of these numbers in the formula mentioned above can also be used.

[0063] This invention can make deformation or modification various by within the limits which is not limited only to the example mentioned above and does not limit a summary. For example, the level of the arbitration of a circuit description, a transistor, a logic gate, or the big group of the arbitration of a component can be used for a template and a circuit. Moreover, an approach is not limited to a logical circuit, a MOS circuit, or an integrated circuit, either. That is, this invention approach can be used for the configuration of the integrated circuit of the large range.

[0064] Drawing 9 shows the example of the equipment which realizes this invention approach. This equipment is equipped with means 90 and 91 to hold the display of a template and each circuit. a template and a circuit display -- counting -- it combines with a means 92 and counting of the number according to individual of the circuit element received from a circuit display means 91 to satisfy the type conditions received from the template display means 90 is carried out. while the number which carried out counting expresses a generating rate -- counting -- the template selection means 93 is supplied with a means. While choosing the initial template component which has the minimum generating rate by these, the template buffer 94 which had this chosen is supplied.

[0065] Moreover, the above-mentioned equipment is equipped with the circuit element selection means 95, and supplies it to the circuit element buffer 96 which had the circuit element chosen by choosing the circuit element which this received from the circuit display means 91 chosen. with two buffers 94 and 96, all the selected components (respectively -- from a template and a circuit) in a juxtaposition shift register structure can be held, and a component can be pushed to this structure, or from this structure, it can carry out pop so that in a pushdown stack for these components. But the verification means 97 compares the component chosen recently. With a verification means, the selected circuitry component tests whether the connection pattern to the circuit element chosen as the early stage of the type conditions over a template component or the selected circuit element buffer 96 is satisfied. A success of a test lays a following template and a following circuit element in a buffer 94 and 96. The sub circuit beforehand prescribed that a success is obtained to all of circuit element components is found out, and a circuit element selection means takes out a signal.

[0066] If a comparison goes wrong, pop will be carried out from the circuit element buffer 97 which had the circuit element chosen at the end by the circuit element selection means 95 chosen, and the following circuit element will be sent to a buffer 96. When the new following circuit element is not obtained, it carries out pop [ of that of \*\*\*\*\* chosen from the buffer 94 by the template component selection means 93 ] with a circuit element selection means. This processing is continued until failure which is generated in case a sub circuit is found out or the template component buffer 94 serves as empty again and to continue is lost.

[0067] the template component selection means 93 which is the theme of this invention -- counting -- an initial template component is chosen under control of a means. Moreover, other

template components can also be chosen according to the thing of the arbitration of the weighting technique mentioned above. \*\* -- time amount is needed before the sub circuit which made it like, the circuit element selection means 95 needed to push in the buffer 96, and subsequently carried out pop-off again, therefore was specified beforehand is detected.

## CLAIMS

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### [Claim(s)]

[Claim 1] As opposed to the type conditions to which each specification relates in detecting the sub circuit of the electrical circuit equivalence object beforehand specified according to the type conditions to which a template circuit equipped with the pattern of the interconnect section between the interconnect template components of a template circuit and each interconnect template component relate Counting of the generating rate according to individual of the circuit element of the electrical circuit equivalence object with which are satisfied of the above-mentioned type conditions is carried out. The initial template component with which type conditions are equivalent to the minimum generating rate is chosen. The initial circuit element with which are satisfied of the type conditions over an initial template component is chosen. In an electrical circuit equivalence object, it interconnects in an initial circuit element according to said pattern. How to detect the sub circuit where the electrical circuit equivalence object characterized by searching for other sequential circuit elements with which it is satisfied of the type conditions of a template component until all template components are identified or a persistent fault is satisfied was specified beforehand.

[Claim 2] Constitute a series of template components in increment, and it leaves with an initial template component. It is chosen under a limit for which this interconnects the template component of the rear group of a series of template components following the pre-group of said a series of template components in a pre-group according to a pre-group pattern. So that the circuit element of related others which has the interconnect to the circuit element which satisfied the type conditions related to each template component, and was before chosen according to the pre-group pattern may be continuously chosen in order of said a series of template components How to detect the sub circuit where the electrical circuit equivalence object according to claim 1 characterized by carrying out was specified beforehand.

[Claim 3] How to detect the sub circuit where the electrical circuit equivalence object according to claim 2 characterized by making it determine by [ both ] having the minimum generating rate of a circuit element [ / selection / of the following template component ] in case a pre-group limit leaves selection was specified beforehand.

[Claim 4] it be the approach of detect the sub circuit where the electrical circuit equivalence object according to claim 3 characterize by restrict to the circuit element which readjust the generating rate of a template component by remove from the generating rate of other pre-groups equipped with other related circuit elements before choose a consecutive template component and , by which the generating rate be connected to other pre-groups again be specified beforehand .

[Claim 5] It is the approach of detecting the sub circuit where the electrical circuit equivalence object according to claim 2, 3, or 4 characterized by re-opting for selection of a consecutive template component by having the highest connection count of the connection of the pattern which connects a pre-group to a consecutive template component was specified beforehand , when a re-limit leaves selection .

[Claim 6] it be an approach of detect the sub circuit the electrical circuit equivalence object of a publication be beforehand specified in which term of the claims 1 - 5 characterize by re-opt for selection of a consecutive template component by have the same interconnect to the pre-group of the same type conditions as the template component which carry out counting of the juxtaposition count , and said pattern at a circuit , when a re-limit leave selection .

[Claim 7] Generate a series of description of an electrical circuit, and it starts by the initial description by the component and its connection. The consecutiveness value of the description of said single string generated by the sequential permutation of the component by the sub circuit which performs each function of said component is advanced. It is the approach of manufacturing the processing mask for manufacturing an integration semiconductor circuit as it ends by the layout description generated to said processing mask under the control which applies said pattern to the processing mask which an integrated circuit advances and performs a function. It has the feedback step which checks a sequential permutation in order to amend a sequential permutation according to a request. This feedback step leaves the intermediate description from said a series of description. The description reconfigured by advancing the template for activation of an effective component and generating of the sub circuit to adjust, and permuting an effective component is generated. In the processing mask manufacture approach of having been made to perform said check by comparing said reconstruction description with the precedence value description preceded with the intermediate description of description of said single string How to manufacture the processing mask for



manufacturing the integration semiconductor circuit characterized by carrying out detection of generating of said sub circuit to which term of claims 1-6 according to the approach of a publication.

[Claim 8] In the equipment which detects the sub circuit where the electrical circuit equivalence object was beforehand specified according to the pattern of interconnect between the template components which interconnected, and each type conditions of the template component which interconnected counting which carries out counting of the generating rate of the electrical circuit equivalence object of a circuit element of satisfying type conditions -- with a means A template component selection means to choose the initial template component with which it has the input terminal which receives generating rate, and type conditions are equivalent to the minimum generating rate, A circuit element selection means to choose the initial circuit element with which it has the input terminal which receives an initial template component, and is satisfied of the type conditions over an initial template component, Equipment which detects the sub circuit where the electrical circuit equivalence object characterized by the arc equipped with a retrieval means to search for other circuit elements of said electrical circuit equivalence object in succession in case other circuit elements connect with the initial circuit element with which it is satisfied of each type conditions according to said pattern was specified beforehand.

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条件または選択された回路素子バッファ96の早期に選択された回路素子に対する接続パターンを満足するかどうかをテストする。テストが成功すると次のテンプレートおよび回路素子をバッファ94、96内に載置する。回路素子素子の全部に対し成功が得られると、予め規定されたサブ回路が見いだされ、回路素子選択手段が信号を出す。

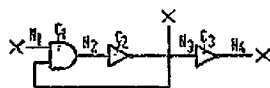
【0066】比較が失敗すると、回路素子選択手段95によって最後に選択された回路素子を選択された回路素子バッファ97からポップし、且つ次の回路素子をバッファ96に送るようにする。新たな次の回路素子が得られない場合には回路素子選択手段によってテンプレート素子選択手段93によりそのバッファ94から選択された回路素子をポップする。サブ回路が見いだされるか、またはテンプレート素子バッファ94が再び空となる際に発生する継続する失敗がなくなるまで、この処理を継続する。

【0067】本発明の主題であるテンプレート素子選択手段93は計数手段の制御の下で初期テンプレート素子を選択する。また、上述した重み付け技術の任意のものに従って他のテンプレート素子を選択することもできる。かようにして、回路素子選択手段95がそのバッファ96内にプッシュする必要があり、次いで再びポップオフし、従って予め規定されたサブ回路が検知される前に時間が必要となる。

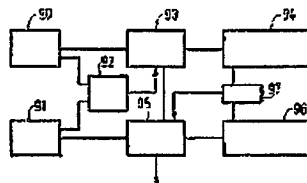
【図面の簡単な説明】

【図1】サブ回路のテンプレートを示す回路図である。\*

【図1】



【図9】



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\* 【図2】第1電気回路の1例を示す回路図である。

【図3】第2電気回路の1例を示す回路図である。

【図4】サブ回路図検出用のフローチャートを示す説明図である。

【図5】サブ回路の発生に対する第1探索のツリー形状の表示を示す説明図である。

【図6】サブ回路の発生に対する第2探索のツリー形状の表示を示す説明図である。

【図7】並列構成素子により大量の探索を行うテンプレート回路を示す回路図である。

【図8】端子の順列配置し得る群を有する構成素子により大量の探索を行うテンプレート回路を示す回路図である。

【図9】本発明方法を実行する装置を示すブロック回路図である。

【符号の説明】

30 初期ステップ

31, 32, 33, 34 探索ステップ

37 テスト

39 レポート段

71, 72, 73, 74 トランジスタ

90, 91 保持手段

92 計数手段

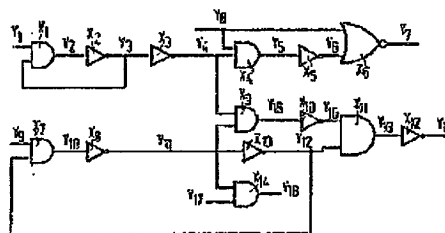
93 テンプレート選択手段

94, 96 バッファ

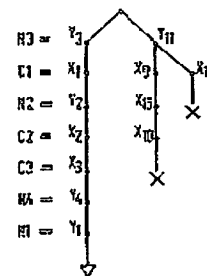
95 回路素子選択手段

97 検証手段

【図2】



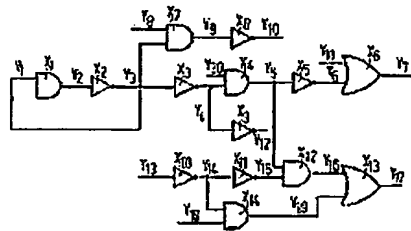
【図6】



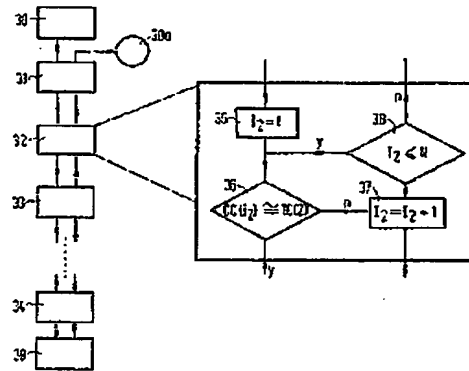
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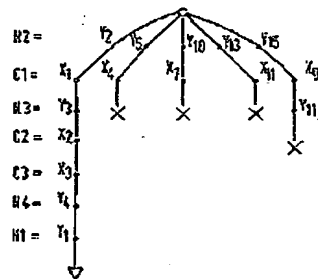
【図3】



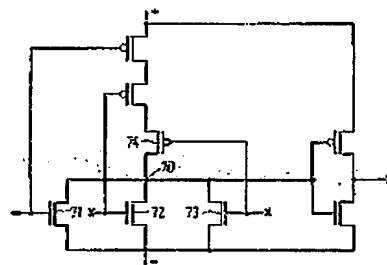
【図4】



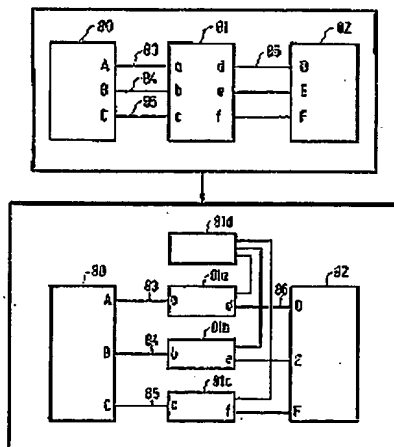
【図5】



【図7】



【図8】



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